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## Case report

## Positional asphyxia in rollover vehicular incidents

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## 1. Introduction

Positional asphyxia occurs when a person is trapped in a position that does not allow for adequate ventilation. In many situations, including the case presented, this type of asphyxia is caused by a seatbelt holding a victim in a head-down position when their car is inverted. Due to strict protocols for routine spinal immobilization in blunt trauma patients, as well as the fact that major vehicular damage frequently accompanies rollover incidents, extrication of victims trapped in an inverted position is often significantly delayed. A previous study comparing routine out-of-hospital spinal immobilization in situations where spinal immobilization is not routinely performed on trauma victims suggests a slightly lower rate of neurologic impairment in patients without spinal immobilization.<sup>4</sup> Given the precarious situation when a patient is trapped in an inverted and life-threatening position, we suggest that it may be more important to quickly remove the victim from the life-threatening position than to spend valuable time attending to spinal immobilization techniques. Depending on the circumstances, it may even be advisable to carefully attempt to turn the vehicle back over with the entrapped patient still inside. We present a case of death due to positional asphyxia in a rollover vehicular incident in which there was absence of lethal anatomically demonstrable traumatic injuries at autopsy. In retrospect, it is probable that the victim would have survived had he been immediately extricated or had the involved vehicle been carefully rolled upright so that the victim was no longer in an inverted position.

## 2. Patient

## 2.1. Case report

A 16-year-old driver with a body mass index (BMI) of 60.8 died after a motor vehicle collision when the vehicle went off the road

and flipped over in a water-filled ditch. He was suspended in an inverted position with his face submerged in water by both lap and harness seatbelts. A passenger, who was able to exit the vehicle, noted that the driver had been conscious, conversant, and able to pull his head and face out of the water. A first-responder was able to help him hold his head out of the water, but prior to extrication by emergency medicine personnel he became less and less conscious and eventually became unresponsive. He was suspended in an inverted position for approximately 15 min total. He was pronounced dead at the scene.

Examination of the body at autopsy showed that the approximately 400 pound adolescent had rare petechiae of the conjunctivae bilaterally. The ears, nose, and lips were congested with florid facial petechiae. Internally, the lungs were markedly congested and air-filled. There was non-occlusive muddy debris focally within the posterior oropharynx and rare bronchi within the right lung. There was a left-sided parietal subscalpular haemorrhage with a greatest diameter of three inches. The remainder of the internal examination was unremarkable, with no evidence of lethal injury. There was no head, neck, or spinal injury. A serum drug screen was positive for caffeine only.

The cause of death was deemed to be positional asphyxia due to the prolonged suspension of the decedent in an inverted position, with a contributing factor of morbid obesity. The manner of death was accident.

## 3. Discussion

Positional asphyxia is a topic that has become increasingly reported in the literature. A study by Conroy et al. showed that almost 30% of asphyxial deaths in motor vehicle accidents (MVAs) are due to positional asphyxia.<sup>3</sup> Bell et al. suggested the following criteria for positional asphyxia<sup>1</sup>:

- The person is discovered in a position that does not allow for adequate breathing.
- The decedent placed himself/herself in the position inadvertently.
- The decedent could not remove himself/herself from the fatal position.
- There is no evidence of internal airway obstruction.
- There is no evidence of carbon monoxide or other suffocating gases.
- There is no evidence of significant cardiac disease.

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The inverted position is one of the more common positions that result in death by positional asphyxiation. Madea suggests two possible causes of death when an individual is trapped in a head-down position: haemodynamic malfunction and the increased work of breathing.<sup>5</sup> Likely, the pathophysiology involves a combination of these two factors, with one or the other predominating, depending on the case.

Belviso et al. showed that the haemodynamic malfunction is due to the combination of increased hydrostatic pressure on the upper body with increased transmural venous pressure in the brain and increased static pressure in the carotid sinus and decreased pressure in the arteries.<sup>2</sup> There is an increased work of breathing partly due to the weight of the abdominal contents pressing on the diaphragm which Uchigasaki et al. discovered in rabbits suspended by their feet.<sup>9</sup> Purdue et al. showed that the stretching effect can tense the abdominal muscles and fix the chest in expiration.<sup>7</sup> In addition, if the individual's arms are hanging freely, they cause tension in the opposite direction, fixing the chest in inspiration. These opposing forces make it difficult for an individual to respire in either phase.

As opposed to the definition of positional asphyxia as described by Bell et al., we would like to suggest that the decedent does not necessarily "place himself/herself" in the fatal position, but often involuntarily ends up in such a position. In our case, a rollover motor vehicle incident was responsible for placing the victim in the inverted position. Positional asphyxia also needs to be clearly differentiated from traumatic or mechanical asphyxia, where breathing cannot occur due to a crush injury. To suggest that injury or death is solely due to positional asphyxia, there needs to be absence of other severe or potentially lethal injuries. If other severe/lethal injuries are present, positional asphyxia may be considered contributory to the overall injury complex or cause of death if there is evidence of positional asphyxia (history of inverted body position and facial or conjunctival petechiae). In our case, the individual had no evidence of a lethal injury. Petechiae were found in the conjunctivae, ears, nose, lips and lungs, all consistent with positional asphyxia.

There are several factors that can contribute to an individual's being stuck in a lethal body position. Alcohol intoxication has been reported as a significant contributor to the decedent's inability to extricate himself or herself from a fatal position.<sup>6</sup> This situation tends to occur more frequently in settings outside of motor vehicles, for example when a drunken individual passes out, falls off of a bed, and becomes unconscious in an inverted position. In our case, alcohol was not a factor. Vega and Adams suggested that obesity is a significant risk factor in being unable to remove oneself from an inverted position,<sup>10</sup> as was likely the case in the case discussed. Seatbelt entrapment is another major contributor to positional asphyxia. In the Conroy study, over 50% of the individuals who died of positional asphyxia were wearing a seatbelt.<sup>3</sup>

An article in *Injury* showed that of victims who die within the first twelve hours of a MVA, half die in the first 5 min.<sup>8</sup> Two-thirds of those who die in the first twelve hours die in the first 25 min. These staggering numbers demonstrate the need for prompt and efficient medical care at the scene. Of particular significance is the need to consider a more rapid extrication of patients without spinal stabilization if their clinical status appears to be worsening. Conroy et al. showed that 13.5% of deaths pronounced at the scene involved lengthy extrications or delayed EMS notification.<sup>3</sup> Their study suggests that some deaths could have been prevented with early extrication.

Immobilizing a patient in an inverted position is a time-consuming practice that, when done unnecessarily, can cost lives. Current EMS policies in many jurisdictions require immobilization if the victim has an altered mental status. In an inverted individual, an altered mental status can be early evidence of hypoxia due to

their body position; in these cases, returning their body to an upright position could be more important than immobilization. A study by Hauswald et al. supported the need for discretion in immobilizing patients.<sup>4</sup> They compared trauma patients in Malaysia where none are immobilized with the routine immobilization of all patients in New Mexico. While the study was limited, it showed that immobilization had little or no effect on neurologic outcomes in patients with blunt spinal injuries.

A review of the literature accompanied by our case suggests that lives could be saved by educating first responders to assess and provide care for victims in an inverted position differently than for "routine," non-inverted patients. This is particularly true if the patient is initially noted to be conscious and conversant, but then starts to lose consciousness. A possible solution might be to cut the restraint belt to allow the victim to get "right-side-up" as soon as possible. In certain cases this could be relatively easily accomplished by rescue personnel who understand the need to remove the patient from the dangerous position in a timely manner. Individuals who find themselves inverted, conscious, but unable to unlatch themselves could also free themselves if they had an emergency belt-cutting device readily available in their vehicle. Another option, if it is feared that the victim is rapidly succumbing to positional asphyxia, is to use a tow-truck (or other machinery) or combined manual strength (multiple individuals) to flip the vehicle as carefully as possible with the victim still inside. Such an undertaking is not without risks to the entrapped victim, as well as emergency personnel. It is necessary to conduct further investigation and development of such techniques to ensure the safe manoeuvring of the vehicles; however, in the right circumstances and when properly performed, these manoeuvres may be life-saving. Further studies are recommended in order to determine the best methods for safely extricating victims trapped in such precarious positions.

#### 4. Conclusions

In conclusion, positional asphyxia occurs when an individual is stuck in a body position that does not allow for adequate breathing. Frequently, this involves body inversion. In the case presented, the decedent, who was conversant immediately after the rollover incident, was unable to remove himself from the head-down position. Death from positional asphyxia ensued, likely via a combination of haemodynamic malfunction and respiratory compromise. Had emergency personnel been able to recognize the major role the inverted position played in the deterioration of this individual, and had protocols been in-place for immediate extrication or returning the victim to an upright position, the victim might have been saved. We recommend that EMS protocols be re-evaluated with specific regard to situations where a victim involved in an incident is in an inverted position, particularly when the victim is initially conversant. Immediate extrication without delay, immediate release from safety belts so that the victim can return to an upright position on his/her own accord, or perhaps even attempts at carefully rolling the vehicle so that the patient is no longer inverted are possible techniques that should be investigated in these types of cases.

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